

Abstract

This research aimed to study the appropriate wind patterns that induce satisfactory cross ventilation in third class residential areas of hot- dry climate of central Sudan with focus on Khartoum State, Al Haj Yousuf District, Block 10. The study also tended to investigate factors affecting wind pattern in order to provide natural ventilation. Providing natural ventilation is the main environmental aspect in residential areas, especially in the congested third class areas, where natural ventilation is highly needed. The main problem is lack of wind studies and wind effects on natural cross ventilation in urban residential areas in Sudan where physical planning laws and building regulations are issued with no emphasis on wind studies and its effects on urban residential areas. The study has employed wind analysis tools and techniques, namely wind tunnels, and Computational Fluid Dynamics (CFD). Firstly, two pilot models are studied to train on how to use CFD software. Then five models taken from the study area have been studied. Velocity vectors and directions were plotted in the five models at different heights (1.5m, 4.5m, 7.5m and 10.5m). The results show that the wind speed dropped to 75 % when it collides with buildings. The vortexes appeared in the internal courtyards. The wind regain it is normal speed after 12 times the height of the building. It is noted that, high buildings block the wind to reach lower buildings. Wind speed in the area between the house and boundary wall is ranging from 0.2m/s to 1.2m/s. There is emergence of an area with triangular shape behind the high buildings (four storey) where the speed in this area ranges between zero and 0.75m/s.

The study has concluded that the wind speed around buildings is sufficient to achieve natural ventilation, except in low buildings just behind the high buildings, where the wind speed required for natural ventilation in the dry and hot region is 1m/s. The researcher has recommended that the buildings in third class residential areas should have the same heights where the natural ventilation is needed. i.e. the heights should be uniformed either one storey, two stories, three stories or four storey. The study has necessitated importance of open space with 70m and 100m wide at least in the center of each group of houses with a single or four stories respectively. Buildings should be designed in the form of square or rectangle, and instead of U or Z shapes so as to minimize the generation of vortices and scattered wind in the small yards.

المستخلص

هدفت البحث إلى دراسة أنماط الرياح المناسبة التي توفر التهوية الطبيعية المُرضية في المناطق السكنية من الدرجة الثالثة في منطقة المُناخ الحار- الجاف في وسط السودان بالتركيز على ولاية الخرطوم. منطقة الحاج يوسف مربع 10 موضوع الدراسة، كما هدف أيضا إلى دراسة العوامل التي تؤثر على أنماط الرياح بالمنطقة وذلك لتوفير التهوية الطبيعية فيها. حيث يُعتبر توفير التهوية الطبيعية أحد المظاهر البيئية الرئيسية في المناطق السكنية ، لا سيما المناطق السكنية المكتظة من الدرجة الثالثة ، و التي تكون فيها الحاجة الكبيرة للتهوية الطبيعية. تكمن المشكلة الرئيسة في عدم وجود دراسات عن الرياح وتأثيرها على التهوية الطبيعية في المناطق السكنية في السودان ، كما أن قوانين التخطيط العمرني ولوائح البناء لا تضع أي إهتمام بدراسات الرياح وتأثيرها على المناطق السكنية الحضرية. في البداية تم دراسة نموذجين تجريبيين للتدريب على كيفية استخدام برنامج المحاكاة (CFD) ومن ثم تمت دراسة خمسة نماذج أخرى مأخوذة من منطقة الدراسة نفسها وذلك باستخدام برنامج المحاكاة (CFD)، كما تمت دراسة و قراءة إتجاه و سرعة الرياح في النماذج الخمسة في إرتفاعات مختلفة (1.5م، 4.5م، 7.5م و 10.5م) أظهرت النتائج أن سرعة الرياح إنخفضت إلى 75٪ بعد أن إصطدمت بالمباني وظهرت الدوامات في الفناءات الداخلية، كما عادت الريح لسرعتها العادية بعد 12 مرة إرتفاع المبنى. يلاحظ أن المباني العالية تحجب الهواء من المباني المنخفضة ، كما تتراوح سرعة الرياح في المنطقة بين المنزل والجدار الفاصل من 0.2 م / ث إلى 1.2 م / ث وتظهر منطقة على شكل مثلث خلف المباني العالية (أربعة طوابق) ، حيث تتراوح السرعة في هذه المنطقة بين صفر و 0.75 م / ث. توصل الباحث إلى عدة نتائج أهمها هي أن سرعة الرياح حول المباني كافية للتهوية الطبيعية ، بإستثناء المباني المنخفضة الواقعة خلف المباني العالية ، وأن سرعة الرياح المطلوبة للتهوية الطبيعية في المنطقة الجافة والحارة هي 1 م / ث. أخيراً ، أوصي البحث أن تكون منازل المناطق السكنية من الدرجة الثالثة بنفس الإرتفاع ، أي ان تكون جميع المنازل من طابق واحد أو طابقين أو ثلاثة طوابق أو اربعة طوابق وذلك لإهمية التهوية الطبيعية. كما أوصى الباحث بأهمية الميادين التي يتراوح عرضها بين 100 م و 70 م على الأقل في وسط كل مجموعة من المباني التي تتكون من أربعة طوابق أو طابق واحد علي التوالي وأوصي بفصل المباني المنخفضة الواقعة إلى جانب المباني العالية بميادين بعرض 100 متر على الأقل وتصميم المباني السكنية على شكل مربع أو مستطيل ، وتجنب بناءها على شكل الحرف (U) أو الحرف (Z) وذلك لتقليل ظهور الدوامات والرياح المتفرقة في الأفنية الصغيرة.

Dedication

I dedicate this work to my mother due to her greatest encouragement and prayers, with my full respect.

I would also dedicate it to my family: My wife, sons and my daughters.

I also dedicate this dissertation to my brothers, and my colleagues in the College of Architecture and Planning SUST.

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